Searching for MACHOs in Andromeda with INT

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Abstract. Two teams are using the Isaac Newton Telescope to conduct a microlensing search for massive compact halo objects (MACHOs) in Andromeda. We discuss both the motivation of the surveys and the obstacles they must overcome. The key to success is the spatial distribution of detected events. We present a detailed simulation of this observable.

1. Microlensing towards Andromeda

Two experiments, AGAPE (Ansari et al. 1997) and MEGA (Crotts et al. 1999), have recently commenced observations on the Isaac Newton Telescope Wide-field Camera (INT WFC) with the hope of detecting, for the first time, massive compact halo objects (MACHOs) in another galaxy—Andromeda (M31). Whilst

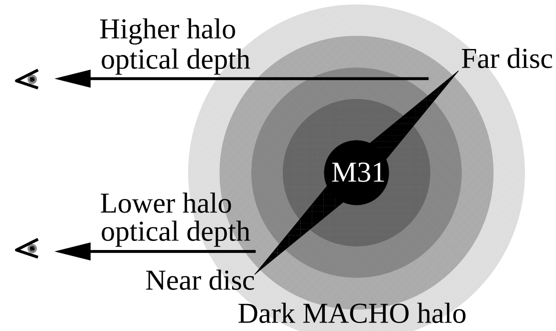

Figure 1. Near-far microlensing asymmetry towards Andromeda. The optical depth is larger towards the far disc than towards the near side if MACHOs are present in Andromeda's halo. The effect is less pronounced if its halo is flattened.

the claim of MACHO detection in our own Galaxy remains hotly disputed, Andromeda's 77° inclination provides a signature which *unambiguously* betrays the presence of MACHOs: near-far asymmetry (Fig. 1). Such spatial asymmetry is unique to M31 MACHOs: it does not occur for foreground Milky Way lenses or for stellar lenses or variable stars in the M31 disc. M31 has other attributes that make it ideal for microlensing studies. It provides $\mathcal{O}(10^3)$ times as many sources than available towards the Magellanic clouds or Milky Way bulge. Its nearby location (770 kpc) permits detailed study of its surface brightness and rotation curve profiles, thus reducing the mass modeling uncertainties which hinder the interpretation of Milky Way microlensing events.

However, the major problem facing surveys probing beyond our own Galaxy is that background stellar fields are not resolved. This means that if a microlens-

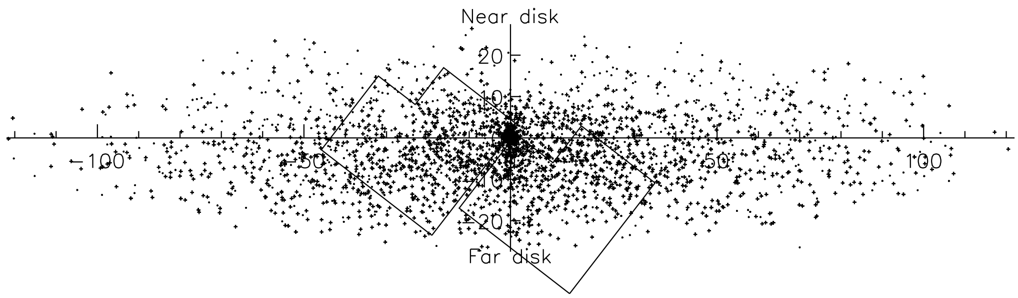

Figure 2. Simulated spatial distribution for 4000 "detected" events.

ing event is detected the source star cannot be identified. It also means that the microlensing signal is contaminated by the background flux of the other stars, making it harder to detect. The problem is made worse by changes in detector alignment, sky backgrounds and observing conditions (especially seeing variations) from one observation to the next. To overcome this AGAPE has developed the *superpixel* technique, whilst MEGA employs *difference imaging*. Both techniques minimize detector, sky and seeing temporal variations so as to maximize the microlensing signal. The two techniques have both been proven in pilot studies and their sensitivity is practically photon noise limited.

2. INT simulations and predictions

We have implemented detailed simulations for the superpixel technique. Fig. 2 shows the predicted spatial distribution for 4000 "detected" events (equivalent to about 20 seasons of data) with the axes in arcmins. It assumes 20 min V-band exposures and allows for the effects of variable sky/moon backgrounds, instrument down-time and typical weather interruptions, all of which determine the experimental flux and temporal sensitivity and thus the observed spatial distribution. The sky background in particular determines the spatial cutoff beyond which no events are detected. The M31 halo events (larger dots) and Milky Way halo and M31 bulge/disc events (smaller dots) are shown for spherical haloes of 0.3 $M_\odot$ lenses and bulge/disc components with a solar-neighbourhood mass function. The locations of the two AGAPE/MEGA INT WFC fields are also indicated. The near-far asymmetry in the M31 halo lenses is clearly evident (e.g. compare event densities at ± 15 arcmin on the minor axis). The simulations predict up to ~ 50 events per INT WFC field per season if MACHOs in the range $\sim 10^{-3} - 3\ M_\odot$ comprise the dark matter. This is sufficient to establish near-far asymmetry within a few INT observing seasons or, if asymmetry is absent, to begin placing constraints on the M31 MACHO contribution.

References

Ansari R. et al., 1997, A&A, 324, 843

Crotts A. et al., 1999, these proceedings